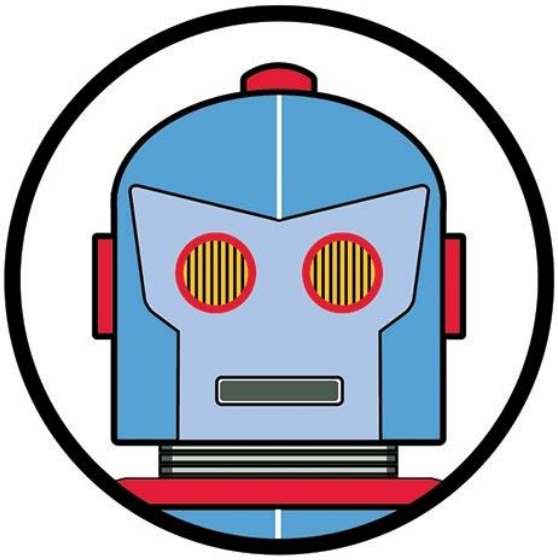
7700R
Rolling Robots



Rolling Robots™

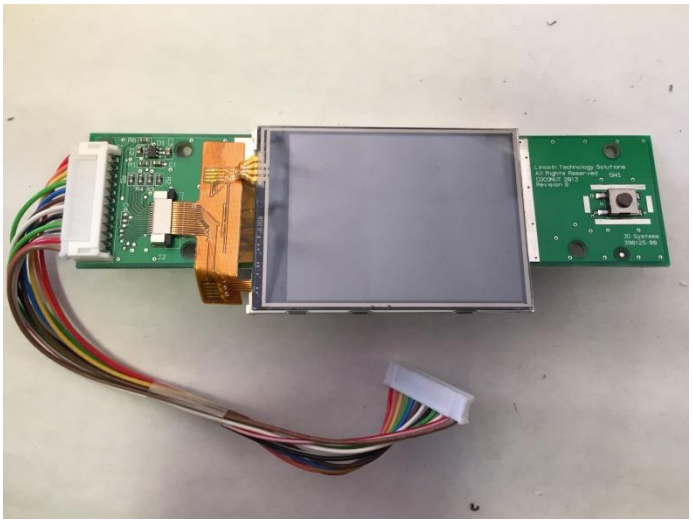
Texas Instruments Electronics Online Challenge

Analysis of a 3D Systems Cube 3 3D Printer

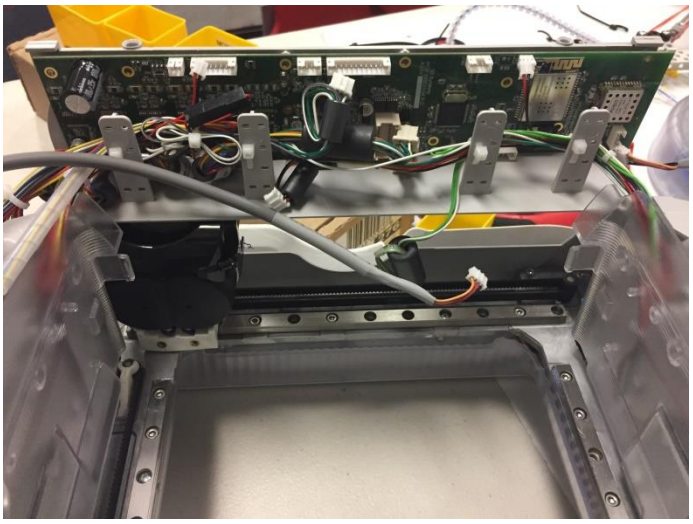
Recent development in 3D printers increased access to rapid prototyping, and a whole new consumer market. Most consumer-end 3D printers use the technique FDM (fused deposition modeling), and works by laying layers of molten plastic on a platform. This process, is common in the 3D printing industry, and is the most cost effective. Because we wanted to learn more about the technology behind 3D printing, we have decided to take apart a 3D-Systems Cube, 3D printer.

The first step in disassembly was removing the screws holding in the front panel. Removal of this panel provides access to two PCB's.

3D systems cube before any un-assembly



PCB for the LCD touch screen: a Lincoln technology solutions coconut revision B.

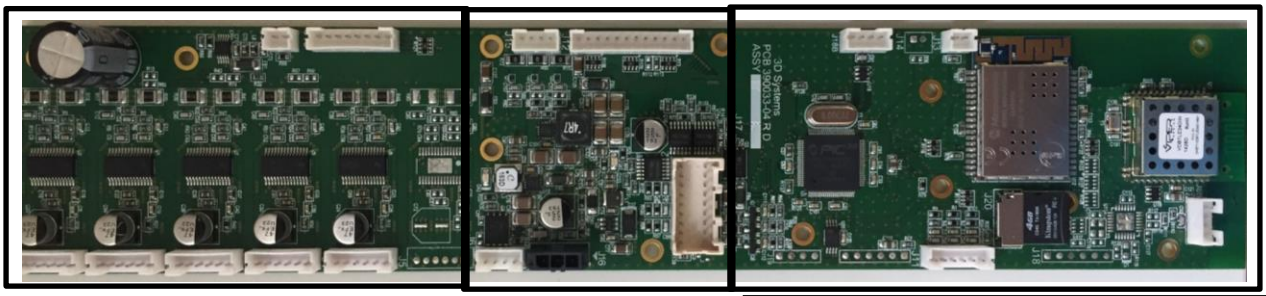


Main PCB still mounted into the inner frame of the 3D printer with wires unplugged.

Within the main PCB, we found numerous parts and were able to identify the following:

- (1) Microchip MRF24WG0MA chip
- (1) Viper VDBTLE24
- (1) Microchip PIC32MX695F512L
- (5) 47 EFK. U23 transistor amplifiers
- (5) Texas instruments DRV8811
- (1) Nichicon 35 V, 1000µ farad capacitor
- (3) STmicroelectronics VN5050AJ-E
- (1) AVX .4R7 inductor
- (2) Microchip MCP 87130U7MF
- (1) Microchip 23K256
- (5) Minebea 17PM-K stepper motors

To simplify analysis, we divided the main PCB into 3 sections.



Section 3 of main PCB	Section 2 of main PCB	Section 1 of main PCB

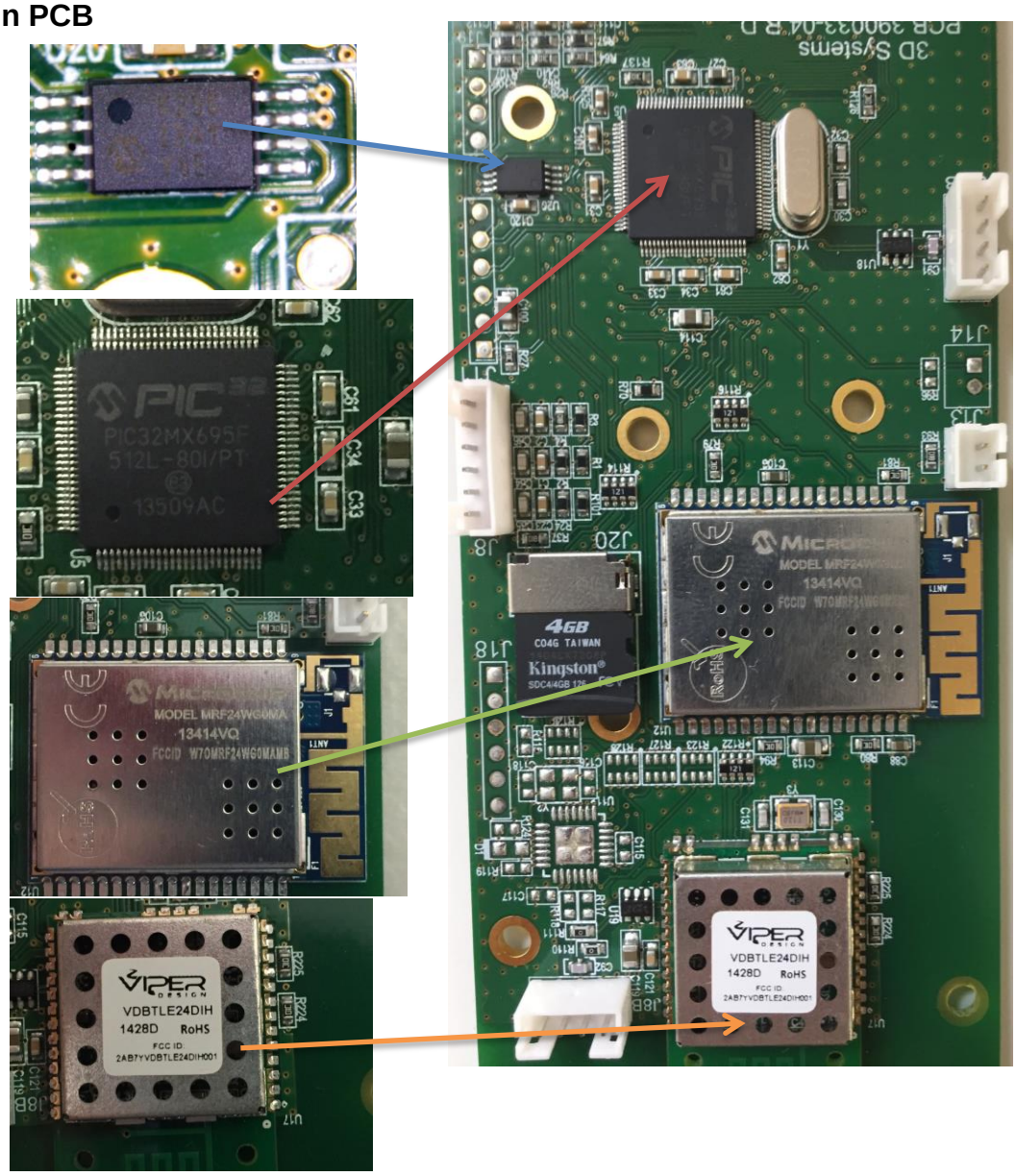
Section one of main PCB

Microchip 23K256:
This chip is a low power serial SRAM, with a 32 Byte page, and has a max clock speed of 20 MHz

Microchip PIC32MX695F512L:
This chip is a 32bit processor, with a clock speed of 80 MHz and 512 KB for program storage. This chip

Microchip MRF24WG0MA chip:
This chip is an 802.11 b/g Wi-Fi radio transceiver module with a built in antenna, and transfer rates of up to 54Mbps

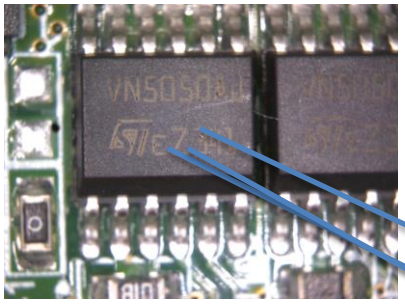
Viper VDBTLE24 chip:
This is a low energy Bluetooth 4.0 chip, which also offers radio, stack, and custom profile support.



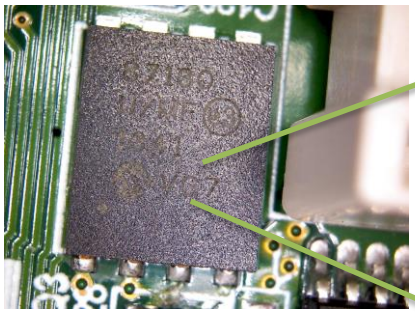
Section 1 contained the major parts of the main PCB. The Microchip MRF24WG0MA chip, lets the 3D printer to connect to Wi-Fi networks. This allows you to send 3D print files wirelessly. The next chip is a Viper VDBTLE24; a low energy Bluetooth 4.0 chip, allowing the 3d printer to communicate with other Bluetooth devices. Then we found the Microchip PIC32MX695F512L: the processor for the 3D printer. This processor controlled all for the 3D printer and analyzed the 3D print "g-code" files. Near the processor, we found a Microchip 23K256 chip which served as the 3D printer's SRAM for various tasks.

Section 2 of main PCB

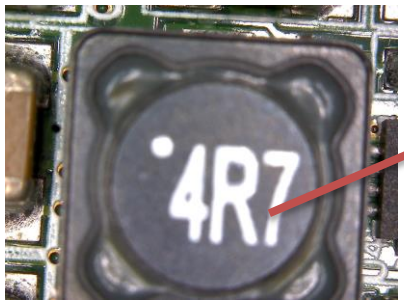
ST microelectronics VN5050AJ-E: This chip is a single high side driver with analog current sense. This means that this chip is a suitable LED driver, for the 3D printer, as it can take high amounts of current.

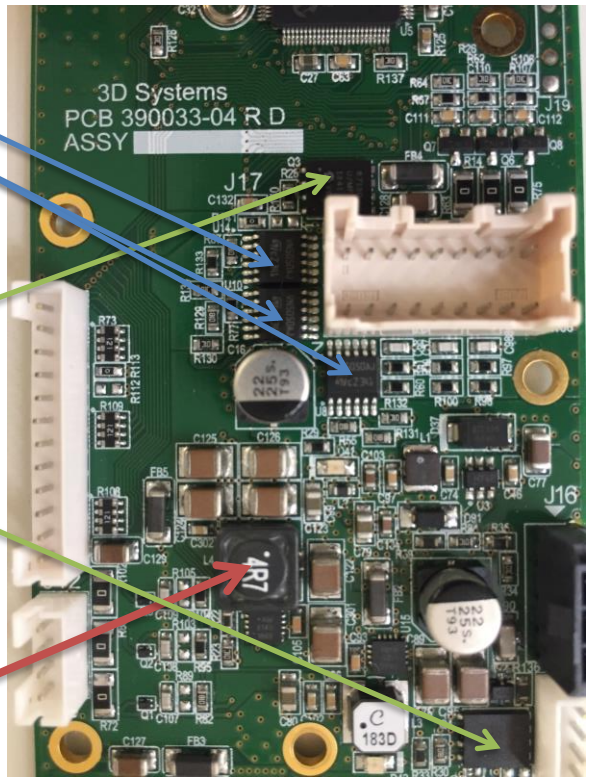


Microchip MCP 87130U7MF: This chip is a high speed n-channel mosfet(metal–oxide–semiconductor field-effect transistor). This means it is a transistor that can amplify or switch electronic signals.



AVX .4R7 inductor: This inductor is an AVX inductor which has an inductance range of 10 to 1000 µH, and a current range from 0.16-1.84 A.

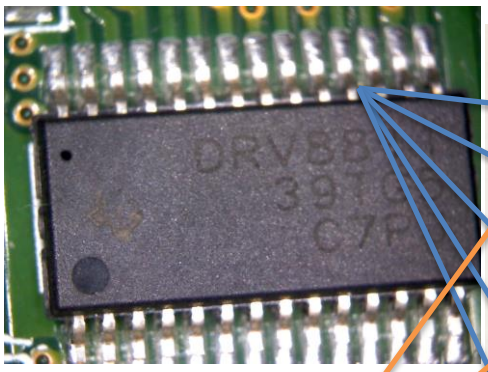




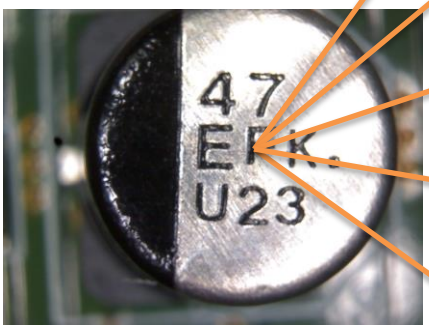
Section 2 contained many components for the USB, and the power supply. We found an AVX.4R7 inductor: a DC/DC converter. This chip decreases the voltage from the power supply to the 3D printer, as it is connected to the power supply. Next we found the Microchip MCP 87130U7MF, allowing the 3D printer to have higher power efficiency by modifying voltage on the main PCB when required. Lastly, we found 3 ST a microelectronicsVN5050AJ-E chip, which serves as an LED driver and as a weaker DC/DC power converter for the USB. Based on chip location, we deduced that two of these chips served as a USB power converter, and the third served as an LED driver.

Section 3 of Main PCB:

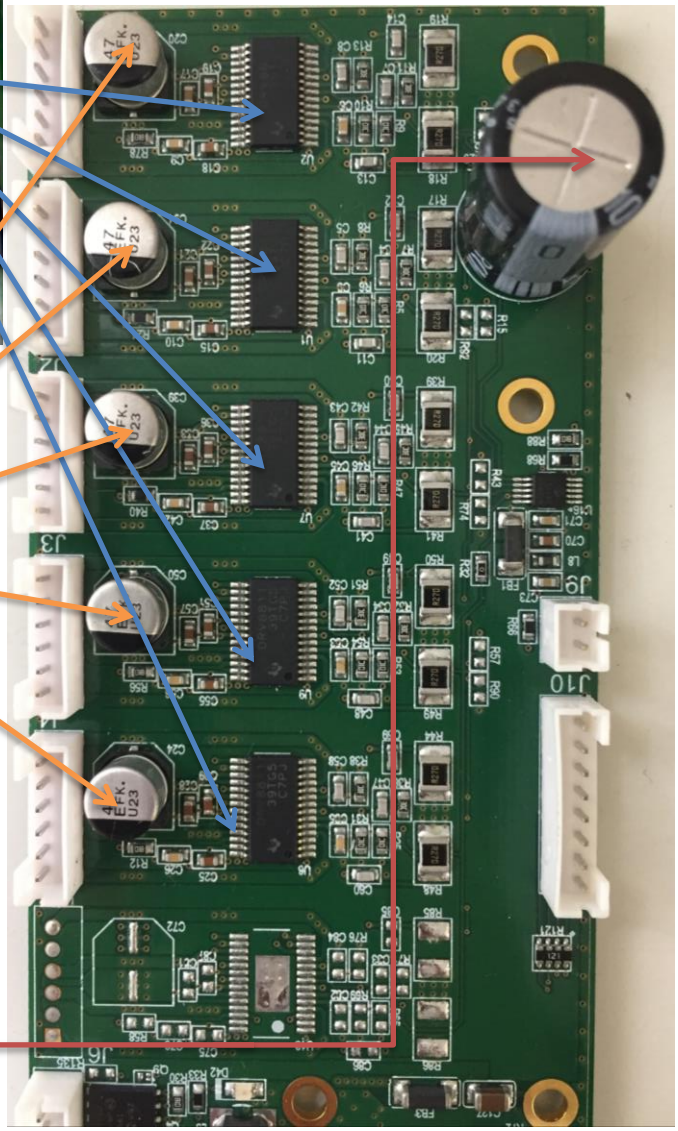
Texas Instruments DRV8811:
This chip is an integrated stepper motor driver which has 1/8 microstepping, and has programmable mixed decay, blanking, and off time.



47 EFK.U23 transistor
The 47 EFK.U23 is a transistor amplifier chip. This means it amplifies the electronic signal from the DRV8811, before the electronic signal reaches the stepper motor.

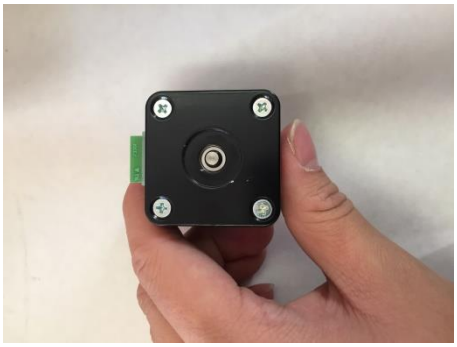


Nichicon 35 V, 1000µ farad capacitor:
A capacitor stores an electrical charge, and can discharge its stored charge in a short amount of time.

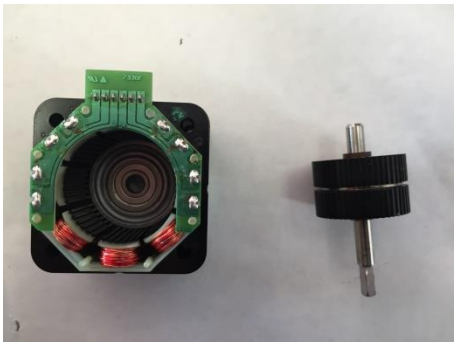


Section 3 of the main PCB contained components which controlled the stepper motors. We found 5 identical circuits, each containing a Texas Instruments DRV8811 stepper motor driver, a 47 EFK.U23 transistor amplifier chip, and a 6 pin output. The DRV8811 utilizes PWM (Pulse width modulation) to control stepper motor speed. The 47 EFK.U23 then amplifies that PWM signal. Lastly, there is a capacitor bank which assists in stepper motor movement.

Stepper Motors:



Minebea 17PM-K stepper motor:
These stepper motors had controlled most of the movement in the 3D printer, and is used for its extreme accuracy, and small size.



Internals of a Stepper Motor: Each stepper motor had 8 small copper coils, whose current turned a gear. Each gear movement from one coil to another is known as a step, hence the name: stepper motor.

5 stepper motors were found inside the cube. These were Minebea 17PM-K stepper motors. Two controlled filament extrusion, and three controlled the x, y and z axis. Each stepper motor is connected to the main PCB, via the 6 pin outputs in section 3.

Conclusion:

Learning how 3D printing essentially works has allowed us to learn how electronics such as a stepper motor, inductor, and transistor work, and how they can be used. 3D printing will be a part of daily life in the future, and this challenge has certainly taught us a lot about it.

Sources:

Wi-Fi chip: http://ww1.microchip.com/downloads/en/DeviceDoc/70686B.pdf

Bluetooth Chip: https://fccid.io/pdf.php?id=2379866

Processor: http://ww1.microchip.com/downloads/en/DeviceDoc/60001156J.pdf

SRAM: http://ww1.microchip.com/downloads/en/DeviceDoc/22100F.pdf

ST driver w/ analog current sense:
http://www.st.com/content/ccc/resource/technical/document/datasheet/a5/a5/cc/12/f9/81/42/3c/CD00151378.pdf/files/CD00151378.pdf/jcr:content/translations/en.CD00151378.pdf

.R47 inductorhttp://datasheets.avx.com/LMXSshG.pdf

High speed n-channel mosfet:
http://ww1.microchip.com/downloads/en/devicedoc/20005159b.pdf

Stepper motor driver: http://www.ti.com/lit/ds/symlink/drv8811.pdf

H-Bridge:
http://www.samwha.co.kr/SW_catalogue/catImage/59/Wire_Wound_Power_Inductor.pdf

Stepper motor: digikey.com/catalog/en/partgroup/17pm-k-series/511